

A GRASP-based approach to the ESICUP problem

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Abstract

The container loading problem is an important problem in the field of logistics and transportation, and it has been extensively studied in the past. It appears that real world problems cannot always be solved easily, due to the large number of complex constraints. The problem addressed in this work was introduced by Renault on the occasion of the 2015 challenge organized by the EURO Special Interest Group on Cutting and Packing (ESICUP).

The main idea of this problem is that a large number of small items have to be packed into containers of different types and sizes. The most important objective is to minimize the volume of the shipped containers. A set of secondary objectives are less common in the academic literature, while they are highly relevant in practice. The problem can be considered as a set of multiple interconnected subproblems: packing the items in stacks, selecting container types and placing the stacks in the selected containers.

Renault ships containers every day. Therefore, one container can be left behind for the next shipment, provided that this container holds the smallest amount of volume and that it contains only a limited percentage of the items of each product. A multi-phase heuristic with a GRASP-based refinement phase was developed. A decomposition strategy during the constructive part of the algorithm enables the solver to repeatedly produce feasible solutions, that are locally improved by post-processing procedures.

Keywords: Bin packing, Container loading, ESICUP

Efficient container loading is a key element in the rapidly changing domain of logistics and transportation. The problem presented for the ESICUP challenge is different from most container loading problems described in literature [2]. In brief, the problem considers putting items in stacks and packing these stacks in containers. Stacks are composed of layers, which in their turn contain rows of similar-size items. One container is left behind for the next shipment. A set of available container types is defined for each problem.

Besides the usual constraints for container loading, related to the size and weight of the items, a number of more specific constraints have to be taken into account. The first constraints determine how items should be packed into stacks. These include, among others, guillotine cut constraints and weight bearing constraints. Furthermore, there are constraints on the materials of the items that can be put in a stack. The most specific constraints relate to the container that is left behind. Shipment can only be postponed for a small percentage of the items of each product type, and the container left behind must be the one holding the smallest amount of volume [1].

The ESICUP challenge problem can be modelled as a logic decomposition of subproblems. To solve the problem, we produced a multi-phase heuristic based on GRASP.

The constructive part of the algorithm consists of different components, each solving one of the interconnected subproblems. The main component of the solver is the ‘bin builder’, which is responsible for packing stacks into containers. Provided that the height of the stacks does not exceed the height of the container, this subproblem can be solved as a 2D bin packing problem with weight constraints. The stack building subproblem, which mainly consists of piling up layers, is solved by another component of our algorithm. Likewise, row building and layer building are handled by separate components.

The algorithm is inspired by the Greedy Randomized Adaptive Search Procedure (GRASP), and can be divided in a constructive phase and a refinement phase. After a feasible solution is obtained, different intensification strategies are applied in parallel. These strategies include a ruin-and-recreate method for rebuilding parts of the solution, a local search based on an ejection chain neighbourhood and a procedure to insert or rearrange the items in a container [4].

Twelve teams of researchers registered for the international challenge. Based on the results obtained during the qualification phase, eight out of the twelve teams were selected for the final phase. The approach presented in this talk produced the best results for both the short runtime (1 hour) and the long runtime (6 hours).

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References

- [1] *Model for the challenge Renault/ESICUP*. 2014.
- [2] Andreas Bortfeldt and Gerhard Wäscher, *Constraints in container loading A state-of-the-art review*, European Journal of Operational Research, 229(1):1-20,2013
- [3] Mutsunori Yagiura, Toshihide Ibaraki and Fred Glover, *An Ejection Chain Approach for the Generalized Assignment Problem*, INFORMS Journal on Computing, 1999